

ENVIRONMENTAL PROTECTION

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USE OF CIRCULATING WATER IN PRODUCTION OF HIGH-VOLTAGE INSULATORS

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The effect of concentrated Na and Ca chlorides and their combination, as well as the effect of return water after filter-pressing, on the properties of molding mixtures, suspensions, air-dried intermediate products, and fired high-voltage porcelain articles is considered. It is demonstrated that the use of return water ensures the preservation of the main technical properties of intermediate articles and the quality of porcelain.

Resource-saving and environment-protection requirements call for decreasing water consumption in industry, including the introduction of circulating water supply. The use of return water after filter-pressing in the production of ceramic household articles is commonly known. The same technology could substantially decrease water consumption in production of high-voltage insulators; however, this requires additional clarification. The effect of the ionic composition of water on the properties of porcelain mixtures was mainly studied with respect to the slip casting technology [1 – 3]. The data on the effect of electrolytes on the properties of plastic mixtures are more scarce [4].

In the course of preparation of a suspension and a molding mixture, ionic exchange takes place between the raw materials and water. A systematic analysis of the composition of the initial water and return water after filter-pressing (Table 1) established an increase in the concentration of alkaline metal and iron ions, as well as organic impurities, with a relatively stable content of alkaline-earth ions. The modification of the ionic composition of water used in dissolving argillaceous components or in milling grog components can modify the chemical composition of porcelain and the parameters of the double electric layer on the surface of clay particles and, consequently, the rheological (molding) properties of suspensions and molding mixtures. However, as can be seen in Table 1, even with full absorption of return-water ions, the variation in the content of the considered ions in the solid phase cannot exceed 0.015%, which is significantly below the precision of component weighing and even the precision of chemical analysis.

Thus, the contamination of the mixture by additionally introduced ions, including iron ions provoked by using return water, is not very probable. It is only the disperse composition of the solid phase that could be modified.

As the ion concentration leading to recharging of the double electric layer is around 10 mg-equ per 100 g of clay components [1, 5], it can be assumed that when the clay-component content in the mixture is about 45% and return water is used, a nearly double reserve exists in the cation exchange capacity. The latter assumption is corroborated by the correlation of the properties of suspensions and samples made using standard water and doubly concentrated (by evaporation) return water (Table 2). The ratios between the moisture values of the suspensions determined by the picnometric method and by drying are supported by the similar rheological properties of the standard and the experimental suspensions. The difference in the strength values of air-dried samples does not exceed the measurement error, i.e., the modification of the ionic composition of the liquid phase has virtually no effect on the properties of the suspension and the intermediate product in air-dried state.

TABLE 1

Ion	Component content, mg-equ/dm ³		
	initial water	return water	
		initial	concentrated
Na ⁺	1.8 – 2.8	4.8 – 7.2	11.5
K ⁺	0.3 – 0.4	0.7 – 0.8	1.7
Ca ²⁺	4.5 – 5.5	5.0 – 5.2	5.0
Mg ²⁺	5.0 – 6.2	3.9 – 5.7	8.0
Fe ²⁺ + Fe ³⁺	0.008 – 0.015	0.014 – 0.024	0.022

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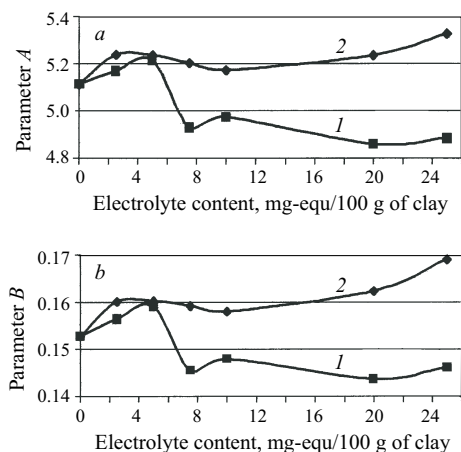


Fig. 1. Dependence of parameters A (a) and B (b) in Eq. (1) on electrolyte content: 1) Ca^{2+} ; 2) Na^{+} .

In order to assess the influence of electrolytes on the properties of a porcelain molding mixture, their effect on plastic strength P_m was investigated according to P. A. Re-binder's method. This parameter characterizes fully enough the deformation properties of plastic mixtures. The value of P_m was measured in mixtures mixed with water and sodium and calcium chloride solutions within the ion concentration interval ranging from 2.5 to 25 mg-eq per 100 g of dry clay components, which provides for a double excess of cations with respect to the cation exchange capacity. The selected moisture interval (17.5 – 21.5%) corresponds to the moisture of mixtures in molding and turning of intermediate articles accepted in industrial practice, with a deviation of $\pm 2\%$ of the absolute value.

The calculation of the plastic state parameters (moisture of rolling limit W_r and fluidity W_f , as well as plastic state in-

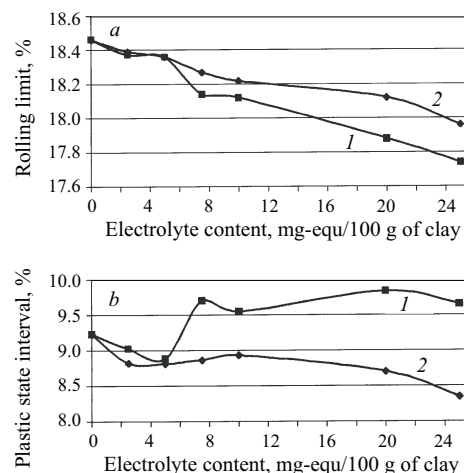


Fig. 2. Dependence of rolling limit (a) and plastic state interval (b) on electrolyte content: 1) Ca^{2+} ; 2) Na^{+} .

terval ΔW) was carried out based on the parameters of the regression equation (Fig. 1) describing the dependence of the logarithm of the plastic strength of the mixture on moisture, according to the method in [6]:

$$\log P_m = A + BW; \quad (1)$$

$$W_r = (\log 190 - A) B^{-1}; \quad (2)$$

$$W_f = (\log 7.6 - A) B^{-1}; \quad (3)$$

$$\Delta W = 1.397 B^{-1}. \quad (4)$$

The fluctuations in the initial water composition modify the electrolyte concentration with respect to the clay components by 0.6 – 2.5 mg-eq/100 g of clay, i.e., the molding mixture properties and the values W_r and ΔW fluctuate insignificantly (Figs. 1 and 2). In the case of using return water, these fluctuations are somewhat greater: from 0.8 to 3.5 mg-eq/100 g clay. In both cases, the parameters determining the deformation properties of the mixture lie within the electrolyte concentration range (below 5 mg-eq/100 g of clay) corresponding to the monotonic variation segments in the considered dependences. The non-monotonic shape of the curves for parameters A and B in Eq. (1), as well as W_r and ΔW at high (5 – 10 mg-eq/100 g clay) concentrations of electrolytes, is presumably due to recharging of the double

TABLE 2

Parameter	Initial water	Concentrated return water
Suspension moisture, %, with fluidity		
10 sec, determined by the method of:		
drying	58.62	56.36
picnometric	58.38	56.20
Bending strength of air-dried samples, MPa	6.4	7.2

TABLE 3

Operation	P_m , kPa	Ion concentration, mg-equ/100 g of clay								
		Na ⁺				Ca ²⁺				Ca ²⁺ : Na ⁺ = 2 : 1 (10)
		0	5	10	20	0	5	10	20	
Molding	140	19.4	19.3	19.1	19.0	19.4	19.3	19.1	18.9	19.1
	122	19.8	19.6	19.5	19.4	19.8	19.6	19.5	19.3	19.5
Turning	230	18.0	17.9	17.8	17.7	18.0	17.9	17.7	17.4	17.8
	151	19.2	19.1	18.9	18.8	19.2	19.1	18.9	18.7	18.9

electric layer on the surface of the clay component of the solid phase.

The combination of salts with the molar ratio $\text{Ca}^{2+} : \text{Na}^+ = 2 : 1$ and the total concentration 10 mg-equ/100 g of clay provides for the medium (around 9.14%) value of the plastic state interval.

The mixtures used for molding as a rule have a moisture of 18.9 – 19.4%, which correlates with the plastic strength equal to 140 – 122 kPa. On adding 10 mg-equ Na^+ , the mixture has a plastic strength of 122 kPa and slightly lower moisture than the moisture of a mixture mixed with water (19.2% against 19.4%). The introduction of the same quantity of Ca^{2+} lowers this parameters to 19.1%.

In turning intermediate articles, the mixture moisture is 19.2 – 18.0%, and its plastic strength is 151 – 230 kPa. The introduction of the same quantities of electrolytes decreases the moisture of the mixtures within this interval of P_m values by 0.2 – 0.3%, which is close to the moisture measurement accuracy (Table 3).

Thus, the use of return water causes variations in the mixture parameters, which do not go beyond the limits accepted in the current production process. The properties of samples molded from such mixtures satisfy the standard requirements (Table 4).

The use of return water has virtually no effect on the technological properties of suspensions, plastic mixtures, and finished high-voltage insulators, and the introduction of a circulating water system makes it possible to save up to 40% water in the production of insulators.

TABLE 4

Parameter	Initial water	Return water
Weight loss, %	5.87	5.69
Density, g/cm ³	2.38	2.37
Bending strength, MPa	86	85
Impact bending, kJ/m ²	1.70	1.70
Breakdown voltage, kV/mm ²	28.3	28.4
Specific resistance, $\Omega \cdot \text{cm}$		
at temperature:		
20°C	4.14×10^{14}	3.3×10^{14}
200°C	1.4×10^2	1.4×10^2

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